



**Gartner
Lee
Associates Limited**

Consulting Engineering
Geologists
Biologists and
Hydrogeologists

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SEISMIC ACTIVITY
IN OVMC CANDIDATE
AREAS

PREPARED BY:
GARTNER LEE ASSOCIATES LIMITED

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Ontario Waste Management Corporation,
2 Bloor Street West,
11th Floor,
Toronto, Ontario,
M4W 3E2.

Attention: Mr. D. Lawrence,
Environmental Coordinator

Dear Sirs:

Re: Seismic Activity -
The Golden Horseshoe

We have completed our literature review of the risk of seismic activity in the Golden Horseshoe to assist in their screening exercise. Our information is presented to especially meet those concerns raised by recent seismic events measured in southern Ontario.

Our research indicates that seismic factors are of only minor significance in the study area. All facilities must be built to the National Building Code standard and as such will meet earthquake requirements. Seismic activity should not be considered as a siting constraint but rather as one of the site specific - design factors to be resolved by the EPCM firm and its experts.

We trust this document meets with your needs at this time.

Yours very truly,

for John A. Anderson
E.G. Anderson, P.Eng.,
Project Director.

PKL:jcm

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SEISMIC ACTIVITY

INTRODUCTION:

This working paper has been prepared to address the potential problems associated with seismic activity in the Golden Horseshoe area of Ontario specifically as it relates to the proposed OWMC site selection and development of facilities. This information is intended to provide a basis for response to concerns that may be raised about earthquakes and their effects upon landfill and treatment facilities. Such concerns have been raised because of recent seismic events, i.e. earthquakes, that have been measured in southern Ontario in September and October 1983.

SEISMIC ACTIVITY:

This section provides some general background to explain the cause of earthquakes and some of the pertinent terminology and significance. A natural earthquake is a disturbance resulting from the release of energy within the earth and the consequent movements which give rise to elastic impulses or waves at the surface of the earth. Earthquakes are classified according to their origin as volcanic or tectonic. In this part of Canada, any seismic activity is related to tectonic origin, i.e. energy build-up and release, within the rocks of the subsurface.

There is a gradual but natural build-up of energy in the deep seated rocks and an earthquake results when this energy is suddenly released and movement occurs. The location of the earthquake is termed its "focus" and the point on the surface directly above that focus is called the "epicentre". The maximum ground displacement will obviously occur at the epicentre. The waves spread out from the focus as the intensity of the ground shaking decreases. The Richter Scale is used worldwide as a basis for measuring the magnitude of an earthquake. This scale is on a logarithmic base. The difference between 1 and 2 on this scale is really a ten-fold increase in the degree of ground vibration and released energy. According to Whitham et al "...a Richter magnitude 5 earthquake will, in general, cause minor damage near the epicentre." Earthquakes above 5 are only expected once in 50 years in eastern Canada even in the moderately active Zone 2 areas. An earthquake above 5 on the Richter Scale can crack plaster and cause weak walls to collapse, but are far from disasters. Those above 6 can be devastating at the focus. Prior to the 1920's, earthquake locations and magnitudes are derived entirely from "felt" reports in Canada and are approximate only. The damage that occurs is then related to the wave motions of the earth and the related vibrations that are transmitted to buildings, structures, services etc.

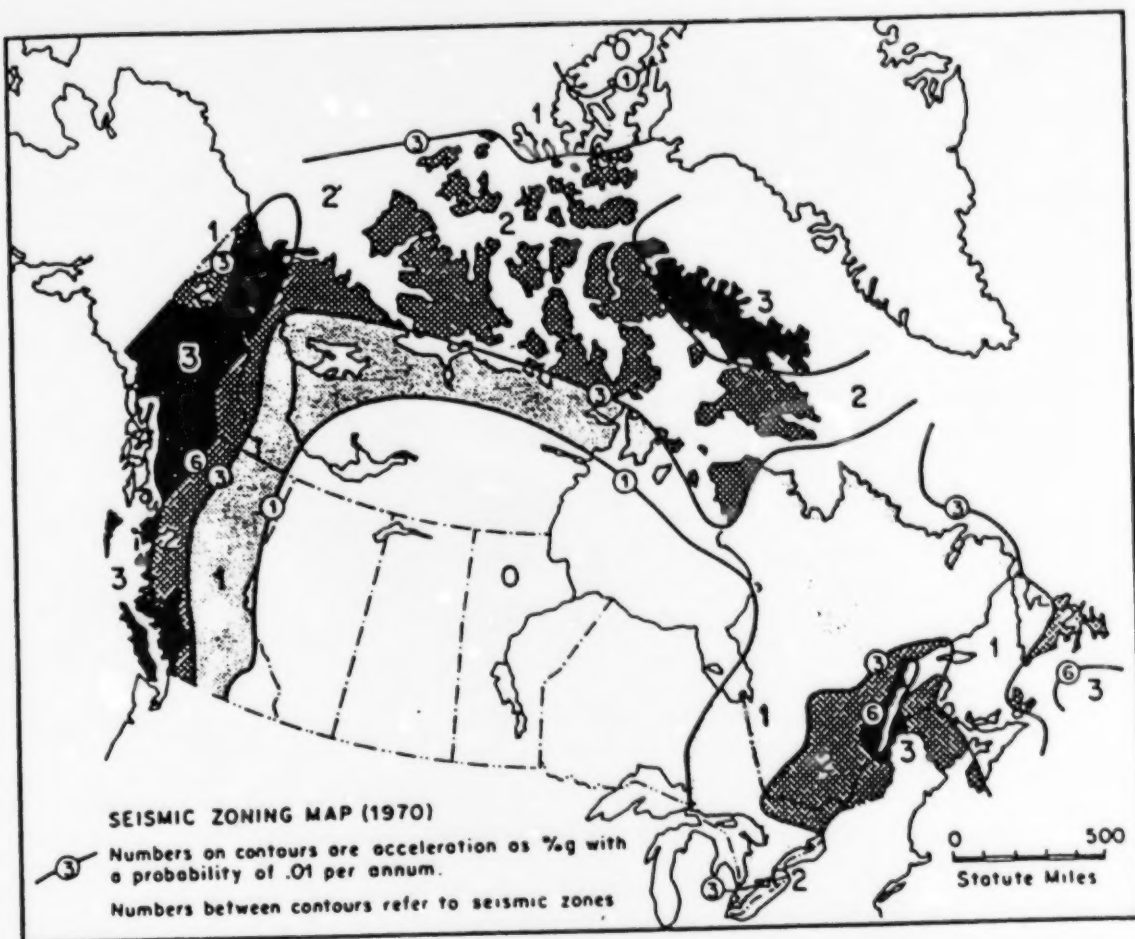
THE CANADIAN/ONTARIO SITUATION:

The Seismic Zoning Map for Canada, 1970, presented in Figure 1, delineates areas of varying seismic hazard. The seismic zone classification system, which was prepared by the Department of Energy, Mines and Resources together with the Division of Building Research and the Canadian National Committee on Earthquake Engineering, is based on specific knowledge of:

- the location, number and frequency of past earthquakes;
- the magnitude (energy released) at the focus of these earthquakes; and
- the significance of this information with respect to likely effects (damage to buildings).

The resulting classification is incorporated into the National Building Code and is used to set minimum acceptable design standards for buildings constructed in Canada.

Under this classification, Canada has been divided into four zones - which are numbered 0, 1, 2 and 3. These zones conservatively correspond with zero, minor, moderate and major damage respectively, at the 1% probability level of damage to structures, which have not been designed to be earthquake resistant. The map is based



Energy, Mines and Resources Canada

FIGURE 1: Seismic zoning map employed by the National Building Code of Canada

on a 100 year reoccurrence period. Where a structure is designed in accordance with the design specifications in the National Building Code, the risk of damage to the structure as a result of an earthquake is substantially reduced.

Most of Canada (Figure 1) is underlain by the fairly stable geology of the Canadian Precambrian Shield. These lands are assigned to Zone 0. It is along the fringe of the Shield, particularly the west coast, the far north and eastern Canada, where most earthquakes occur.

Southern Ontario lies largely within Zone 1. The Niagara Peninsula and the area roughly bounded by Ottawa - Brockville - Cornwall are assigned to Zone 2. Montreal, Ottawa, St. Catharines and Niagara Falls are cities which are also located in Zone 2 areas. Most of southern Ontario is underlain by bedded sedimentary rocks that have been relatively unstressed in geologic times and hence are considered fairly stable. The Ottawa - St. Lawrence Valley seismic activity is related to fault (fracture) zones in the bedrock and the Niagara Peninsula falls into the same category. It should be remembered that Zones 1 and 2 are in the minor to moderate damage categories if an earthquake occurred there.

Figures 2 and 3 show the approximate location of all recorded earthquake epicentres up to 1980 for the Niagara and Halton study areas respectively. It is important to note that only 25 earthquakes have ever been recorded in

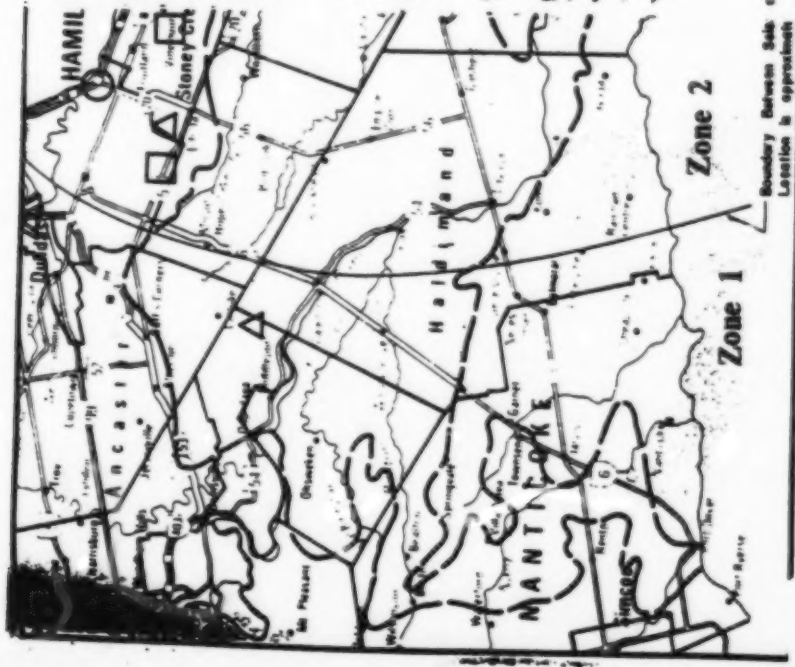


Figure 2

Niagara Study Area APPROXIMATE EARTHQUAKE LOCATIONS

SYMBOL	RICHTER MAGNITUDE
○	0 to 2.9
△	3.0 to 3.9
□	4.0 to 4.9
◇	5.0 to 5.9

NOTE - All locations are approximate locations of the earthquake epicenters. Filled symbols indicate a more reliable location, within 20 km.

Interference in the Department of Energy, Mines and Technical Surveys; Earth Physics



Boundary Between Sub-Location is approximate

Zone 1
Zone 2



Figure 3
Halton Study Area

SYMBOL



RICHTER
MAGNITUDE

0 to 2.9

3.0 to 3.9

4.0 to 4.9

5.0 to 5.9

Approx. Earthquake Locations

NOTE Filled symbols indicate a more reliable location, within 20km.

Approx. locations of earthquake epicentres

0 km 10



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this area and that they fall into the following groupings.

<u>RICHTER SCALE</u>	<u>NO. OF EVENTS</u>
5.0 to 5.9	1
4.0 to 4.9	5
3.0 to 3.9	14
0.0 to 2.9	5

It should be remembered that a Richter Scale of magnitude 5 will in general cause only minor damage near the epicentre and less damage away from the epicentre. Only one event between 5 and 6 has ever been recorded in this area. Each year about 300 earthquakes occur in Canada. Therefore, we are relating to a relatively stable area in southern Ontario. Ninety percent of the earthquakes occur in western and northern Canada. Further, the areas of geologically unstable soils are those of loose density -- saturated sands or sensitive clays -- that tend to liquify when shaken. This is particularly serious where such soils are on steep slopes and will flow. This is not the case in southern Ontario. The clay plains, with stiff to firm soils and moderately undulating topography, of both study areas present a landscape that is of little concern to the effects of earthquake waves.

SIGNIFICANCE TO FACILITIES SITING DEVELOPMENT:

The Halton study area lies within seismic Zone 1 of the National Building Code Classification. The risk of damage to structures, even those not designed in accordance with earthquake design specifications, is conservatively considered to be minor. The National Building Code sets minimum acceptable design standards for buildings so that they will suffer little damage during a moderate earthquake and limited damage, but resist collapsing, during a major one. Seismic risk is minor.

The Niagara study areas lie mainly in "Seismic Zone 2" where risk of damage is considered to be moderate. Obviously, all facilities must be designed in terms of the National Building Code for earthquake loadings, resistances and line loads. This is a routine procedure.

From a siting point of view seismic aspects are of a uniform nature regionally and, therefore, of a regional scale. These are not a siting constraint.

REFERENCES:

Whitham, K., W.G. Milne and W.E.T. Smith
1970: The New Seismic Zoning Map for Canada 1970
Edition, Dept. of Mines, Energy and Resources.

National Building Code